Collaborative Online Embryology

The "Visible Embryo" Project

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George Mason University

Dr. Kent Thornburg
Oregon Health & Science U.

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Eolas Technologies Inc.

Visible Embryo Project Overview

http://netlab.gmu.edu/visembryo

- Deploy a system of visualization/ collaboration workstations using high performance networking
- Digitize embryo data from the Carnegie Collection as a basis for collaboration experiments and make it available via the system
- Demonstrate use of the system in medical collaborations
  - annotation and modeling
  - embryology education
  - clinical management planning
- NGI digital library project supported by NLM

Visible Embryo Project Participants

- GMU - overall direction,
  collaboration technology
- Eolas - technical coordination, software
- AFIP/NMHM - data acquisition
- SDSC - data repository and rendering
- LLNL - network facilitation
- OHSU, UIC, JHU - medical demonstrations

Results of the Visible Embryo Project

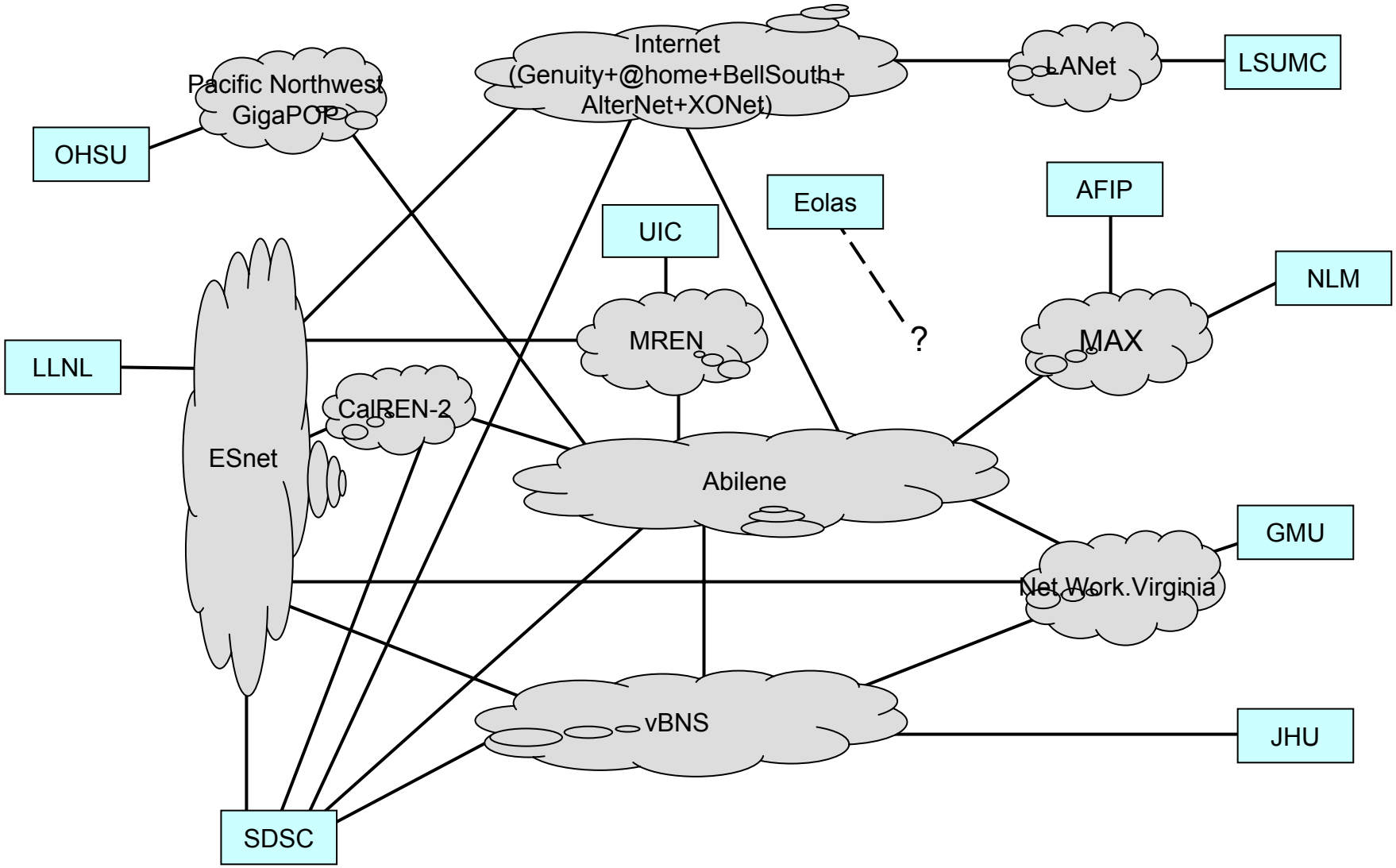
- Collaboration technology
  - collaboration/distance teaching software operational
  - annotator software synchronous & asynchronous
  - all research sites on NGI at OC3
- Repository
  - data collection system streaming digital embryos
    - AFIP to SDSC
  - 21 embryos scanned
  - 4 embryos annotated
  - low-resolution format web-accessible from AFIP
- Medical applications
  - annotation organized to use volunteer labor
  - twenty animations of embryo development
  - in-utero ultrasound comparison underway

Role of NGI in Visible Embryo

- Collaboration for annotation
- Delivery for embryology distance education
- Collaboration for clinical evaluation
- Streaming delivery to repository
- Community access to repository
  - Web access to all via commodity Internet
- Collaboration for project management

Visible Embryo Project -- NGI Connections

by Lawrence Livermore National Lab



Collaboration Workstation

- Equipment: High-end Windows Pentium III
  - 1 GB RAM, 2x18 GB disk, backup tape
  - video camera and mike, scanner, graphic entry tablet
- Software
  - Operating system (Windows 2000)/utility(GroupKit)
  - Data access (streaming)
  - Existing collaboration (MBone tools)
  - SDSC's Storage Request Broker for archive access
- Network:
  - LAN 100M or better
  - WAN OC3 or OC12 to NGI

Data Capture

Ms. Elizabeth Lockett
National Museum of Health and Medicine

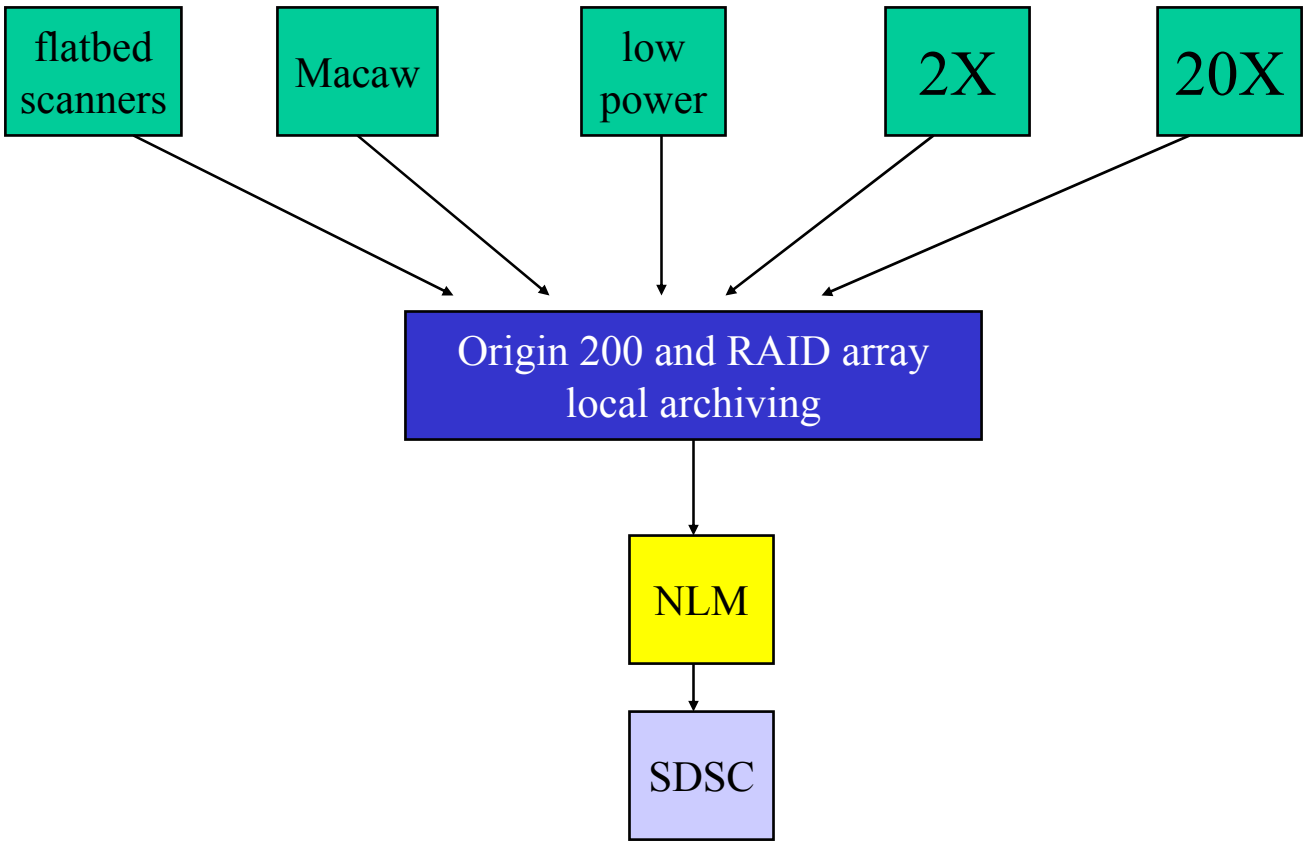
Image Acquisition

Images are captured under 20x magnification using a 2x magnification map of all the sections on the slide. Along with the 20x capture, script creates an unique XML document for each tile image.

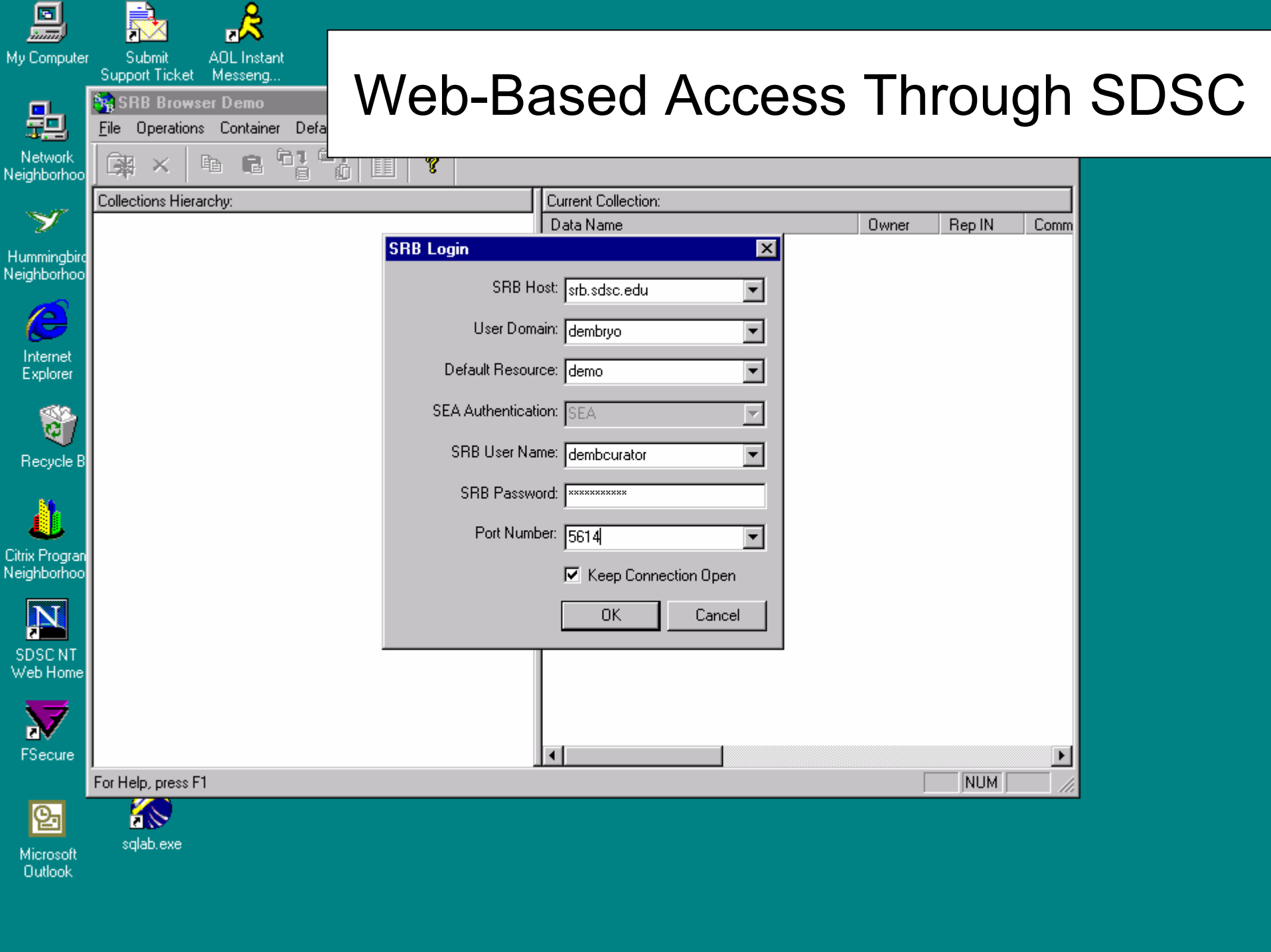
These XML files are used to

- archive images
- composite images

Archiving System



Web-Based Access Through SDSC



Current Collection Statistics

- 21 embryos digitized
- 4 embryos annotated
- Number of files stored
  - 45,365 images
  - both uncompressed and .JPG
  - 39.328 digitized slides at 20X
- Amount of data stored
  - 721 GB today
  - potentially 4TB

Embryology and Gene Expression

Drs. Jeff Pentecost and Kent Thornburg
Oregon Health & Sciences University

Modeling Human Cardiogenesis

Fetal origins of adult heart disease

- Heart disease: leading cause of death in US
  - >59 million Americans affected; ~$260 billion/year
- CHD appears to be a developmental disorder (Barker, 2002)
- Childhood systolic HTN related to reduced gestational growth (Law, 2001)

Mechanisms regulating heart development are poorly understood.

Fetal programming of coronary heart disease. Barker DJ. Trends Endocrinol Metab 2002 Nov;13(9):364-8
Body size at birth and blood pressure among children in developing countries. Law et al Int J. Epidemiol 2001 Feb; 30(1) 57-9

Human Cardiogenesis

<u>3D visualization tools enhance our research in:</u>

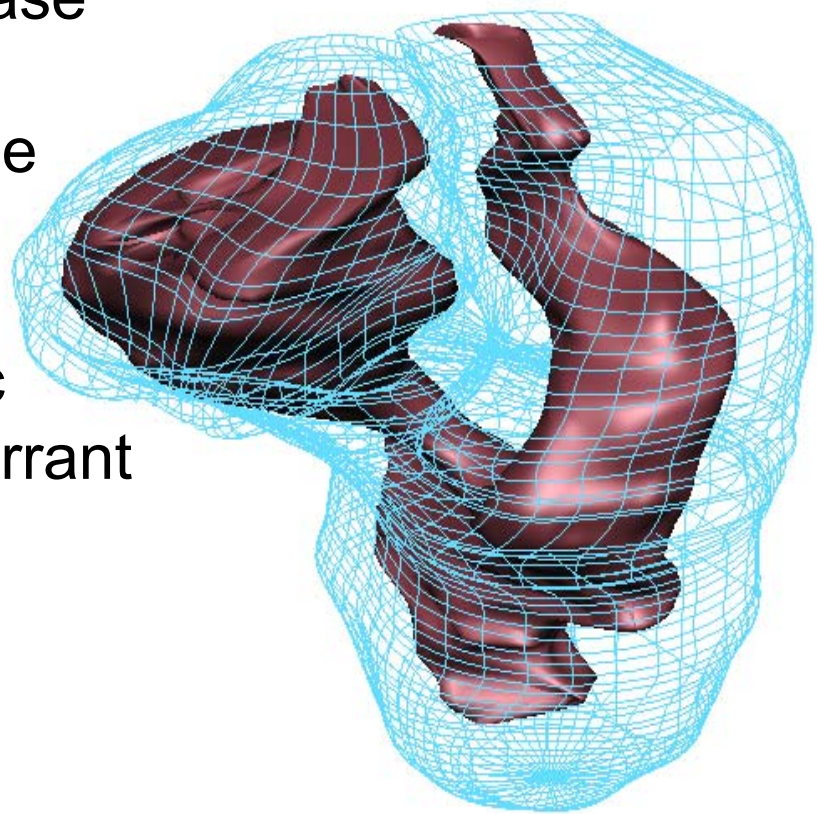
•Fetal origins of adult heart disease

•Anatomical site mapping of gene activity in cardiogenesis

•Cellular, molecular, and genetic mechanisms for normal and aberrant heart formation.

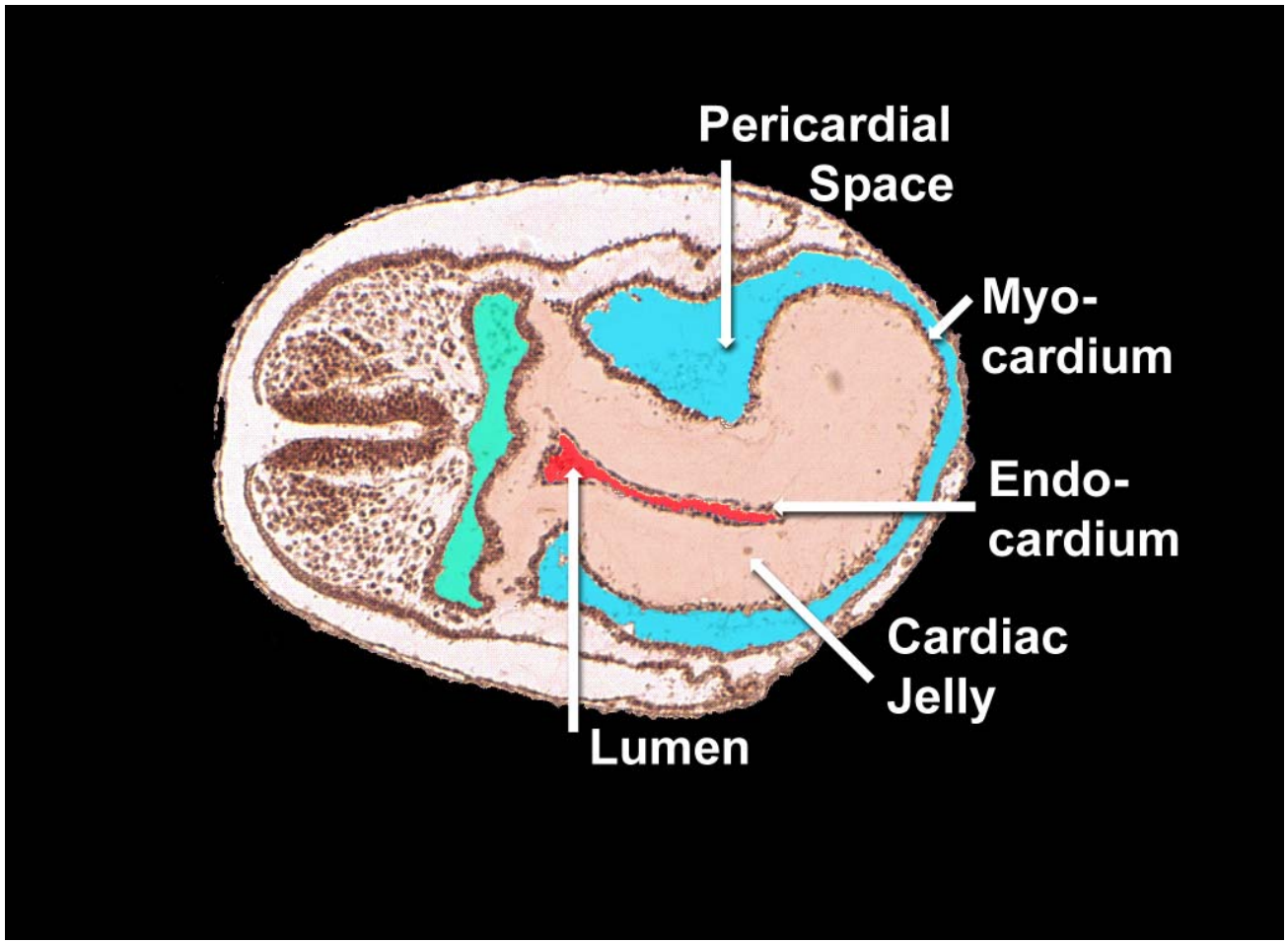
•Gene therapy

•Knowledge base development



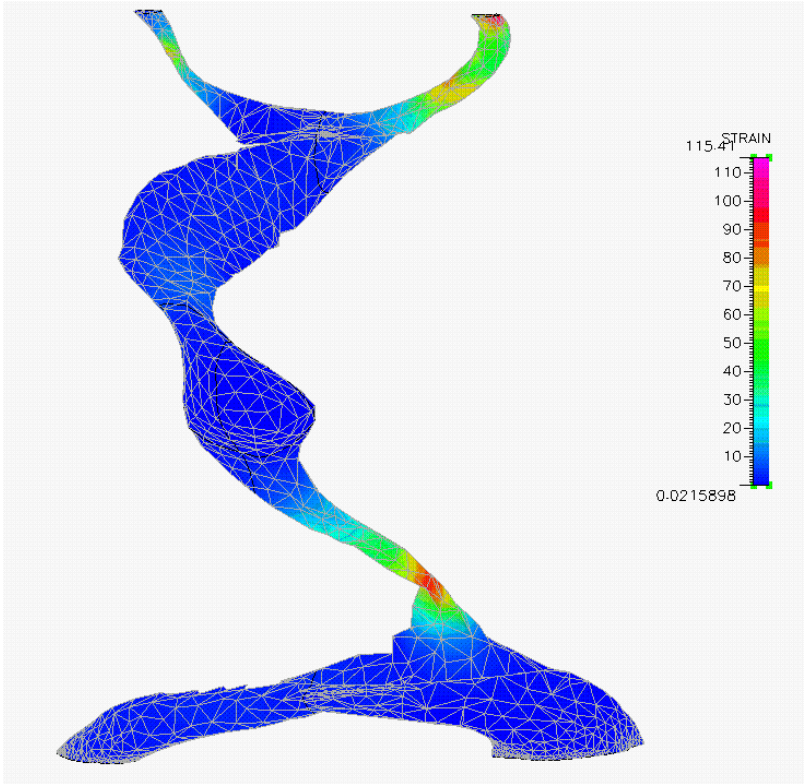
Annotation of histologic images

- 3D spatial coordinate referencing
- creating a nomenclature ontology



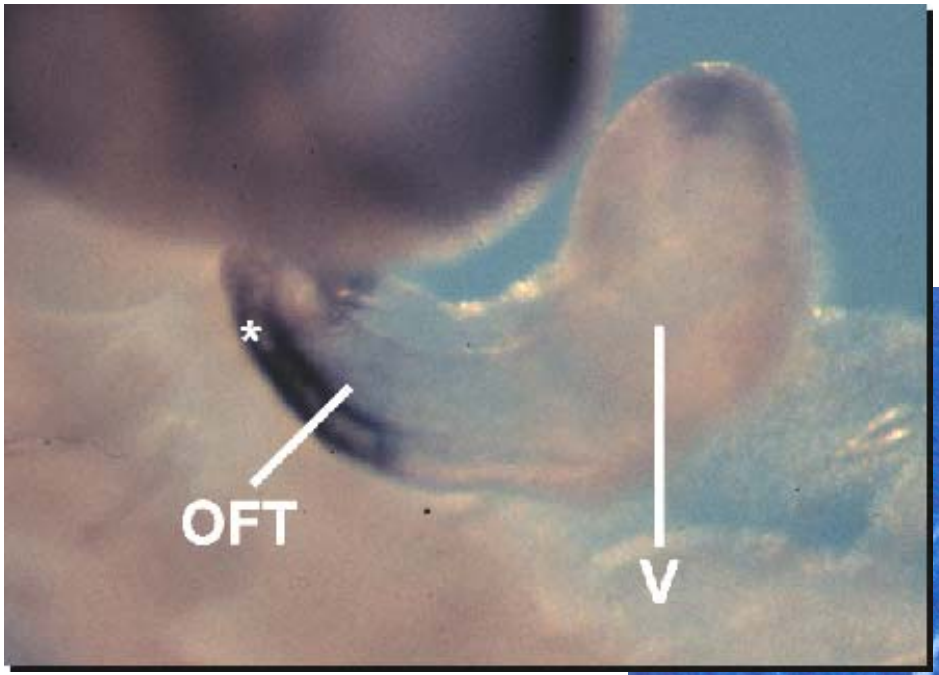
Human Cardiogenesis: Surface Modeling

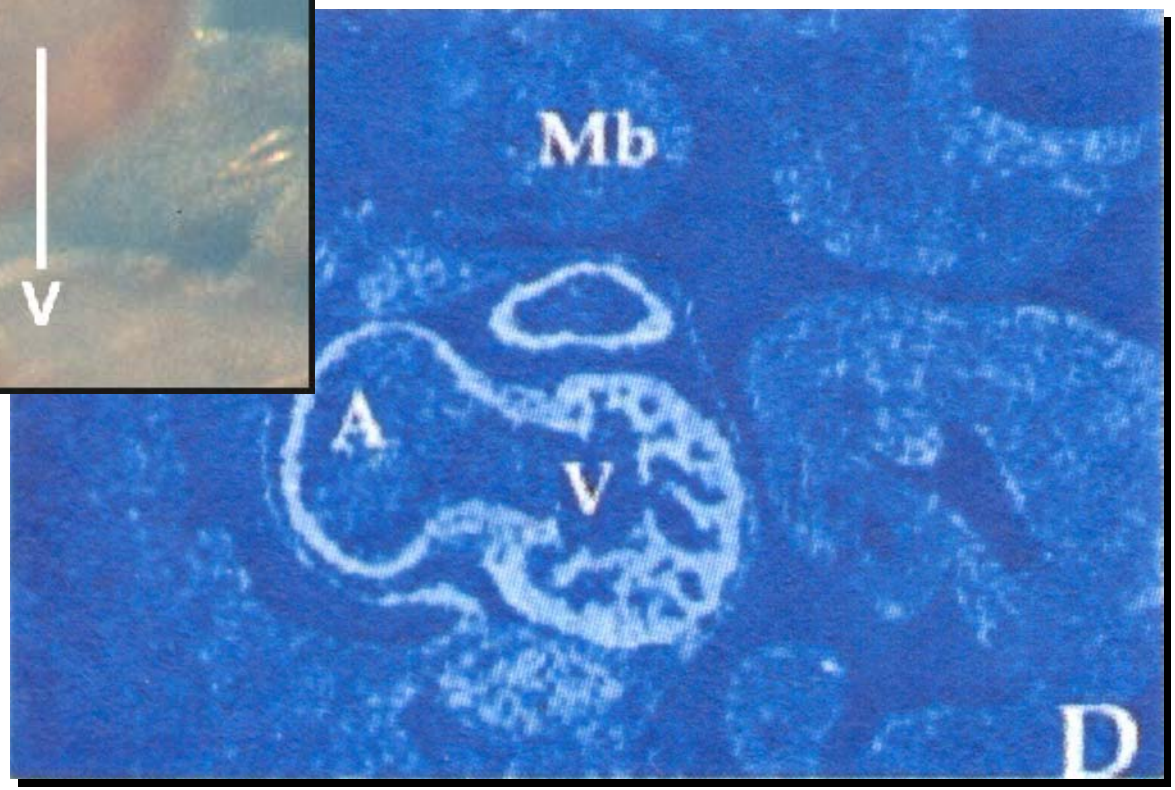
- Computational fluid dynamics: shear stress analysis



DeGroff, et al “Modeling Applications in Congenital Heart Disease: Flow in the Embryonic Heart” Proceedings of ICMMB-11, 2000; 279-281; Pentecost, Sahn, Thornburg. Graphical and stereolithographic models of the developing heart lumen. Comp. Med. Imaging 2001 (25):459-463

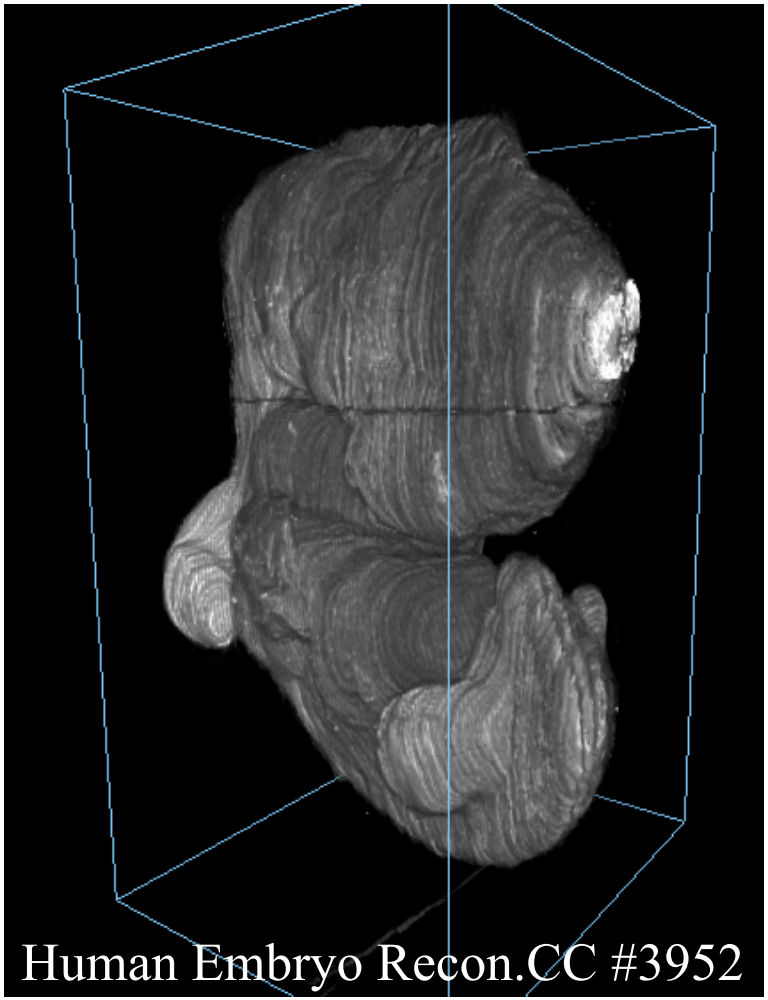
Gene Expression Mapping

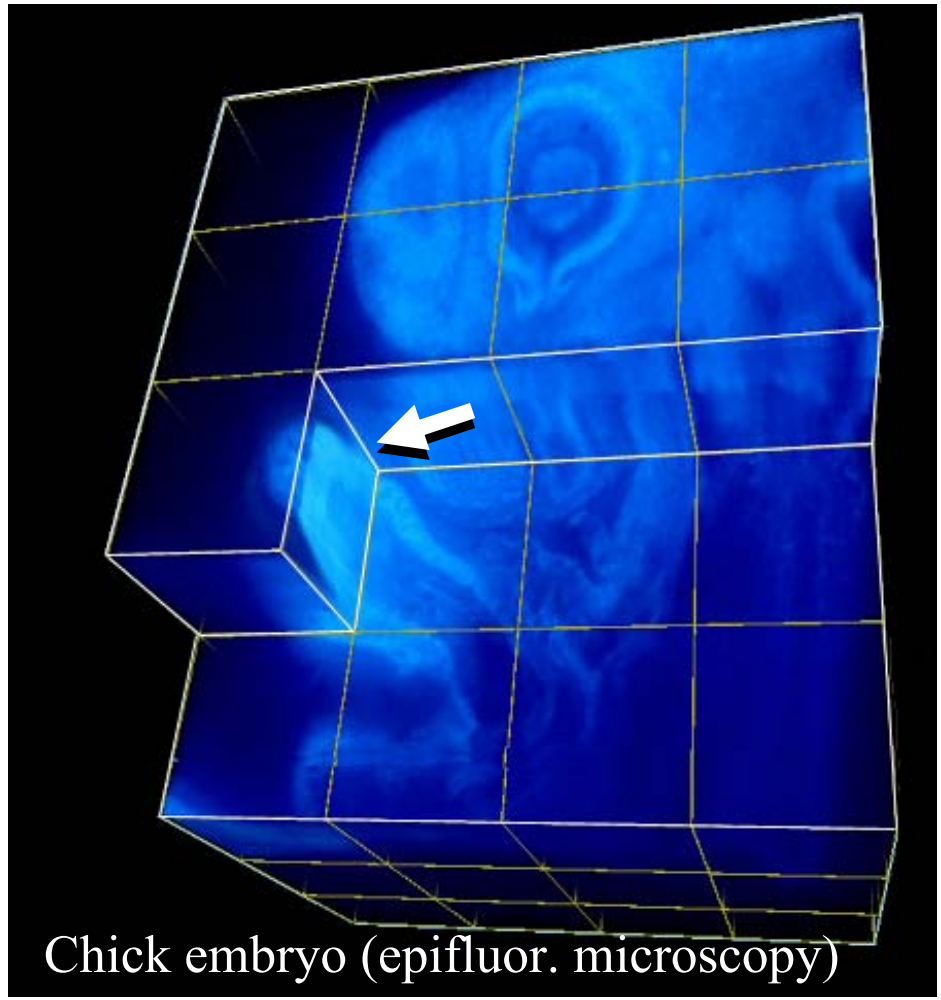




Phosphatase ‘A’ gene expression in the embryonic chick heart w/ traditional 2D images.

Voxel Modeling and Gene Expression Mapping





Embryology Education and Visualization

University of Illinois at Chicago
Mark J. Holterman

Embryology is Fundamental

Provides the basis for understanding:

– Anatomical relationships
– Pathophysiology
– Congenital defects

Embryology Education Status Report

- Medical schools are decreasing class hours
- Few Schools with free standing embryology course
- Shortage of embryology educators
- Minimal testing on National Board Exams

Embryology is a Tough Subject

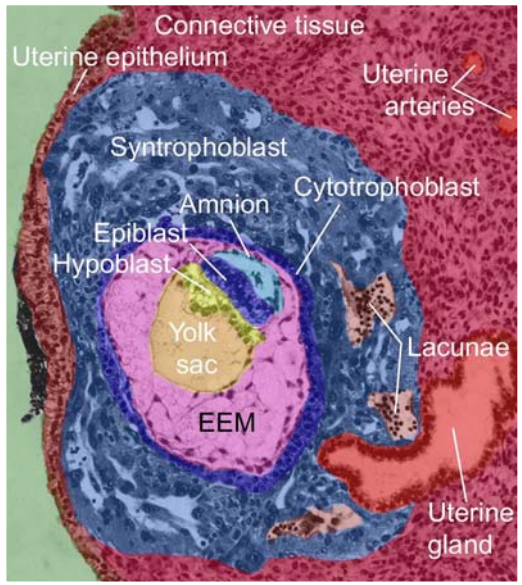
- Fertilized cell to fetus in 10 weeks
- Microscopic changes in the dark
- Organ development occurring in a complexity of folding and growing tissues
- This four dimensional aspect of developmental biology is the major stumbling block for students and educators

How to improve Embryology Education

- Improve the teaching materials
  - computer models
  - 4-D animations of the important steps
  - Interactive teaching software
- Make the best teachers available
  - Distance learning technology

Visualization Approaches

- Highlighted photomicrographs
- 3-D “Reconstructed” embryos
- 4-D Growth and Change
- Interactive learning tools



Network EducationWare
(NEW)

- Live online teaching
- Uses a collection of Internet multicast tools
  - audio, video, whiteboard, record/playback
- Runs over commodity Internet
  - Transport Layer Multicast server
  - Floor control keeps the instructor in charge
- Scaleable from modem rates to NGI
- Open source system

Recorded Class Segment

- Dr. Maury Pescitelli, Embryologist, UIC
- Captured as it would be taught over the net
- Such master classes are a resource for embryology education

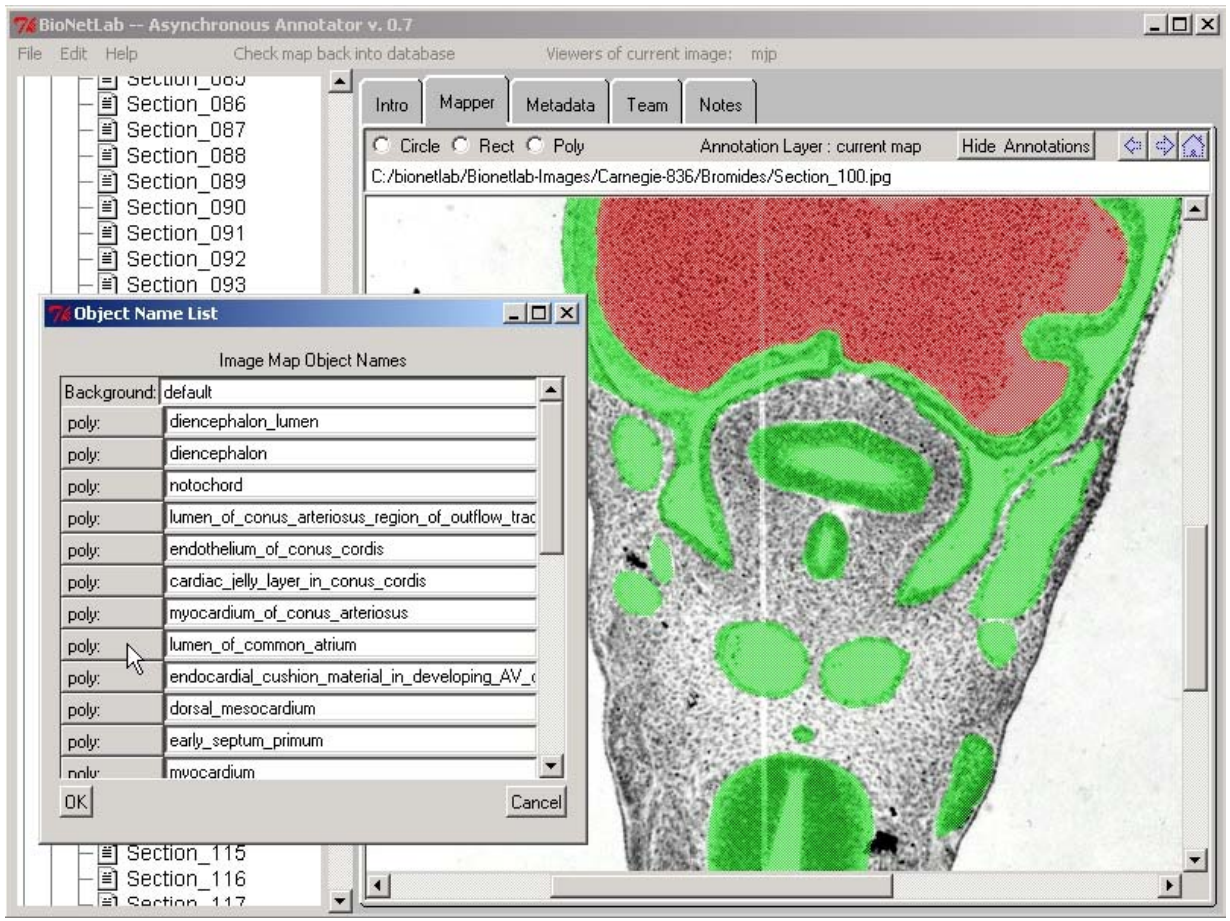
Digital Image Annotator

Dr. Mike Doyle
Eolas Technologies Inc.

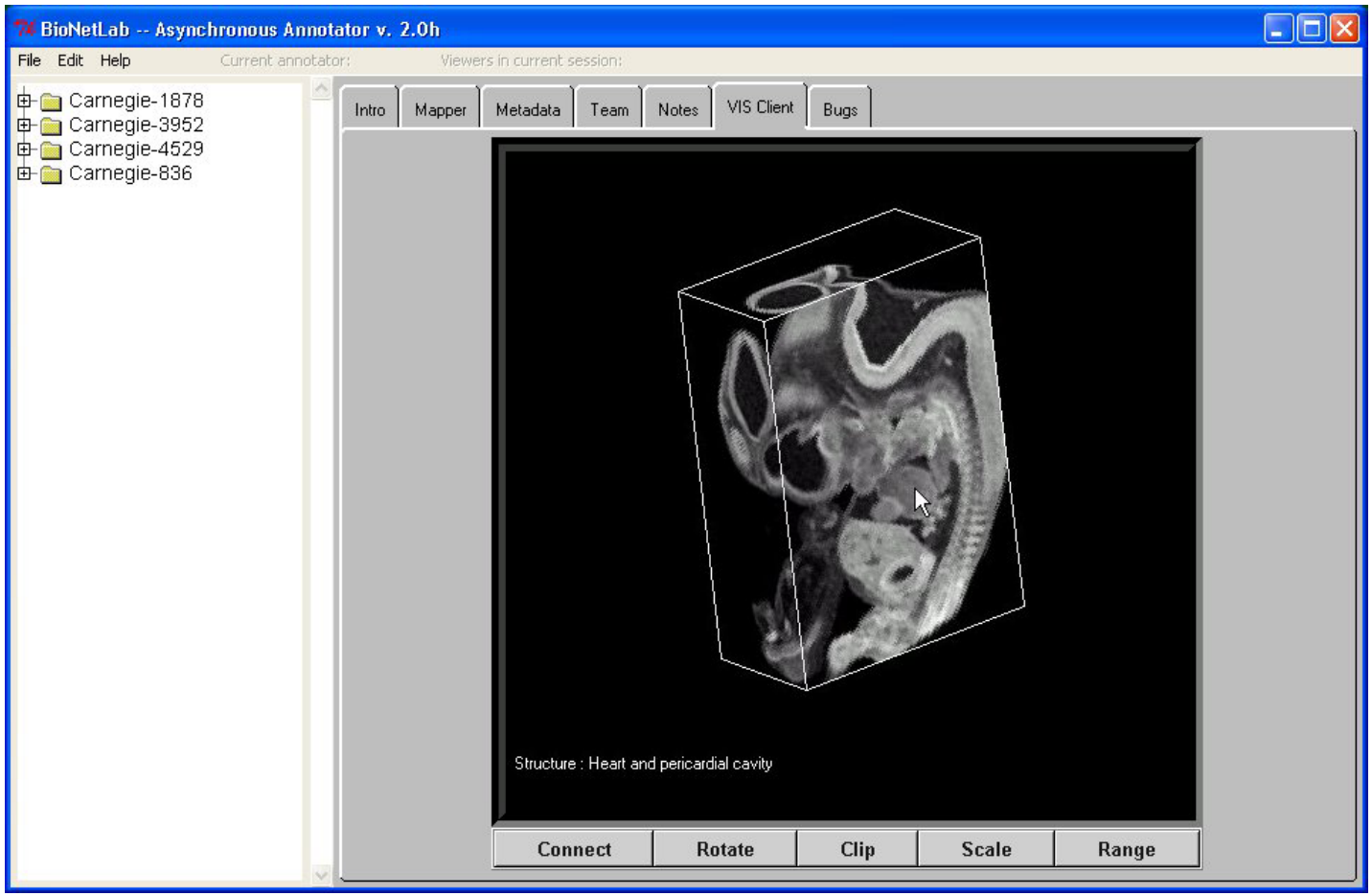
BioNetLab Annotation Collaboration System

- Annotation mapper and knowledgebase
- Metadata browser
- Team coordination interface (pending)
- Notes/Wiki/Files interface
- 3-D volume visualization and map browser
- HTML client & media viewer

BioNetLab Annotation Collaboration System



BioNetLab Annotation Collaboration System



BioNetLab Annotation Collaboration System

- A Few Lessons Were Learned:
  - Synchronous collaboration good for demos, but
  - Asynchronous collaboration much more practical
  - Don’t assume that the bandwidth will be there
    - 2 asynchronous designs were needed
      - High-bandwidth: Network-scope distributed shared arrays
      - Commodity bandwidth: Message-based RPC model

3D Embryo Fly-through

Drs. Reagan Moore and Steve Cutchin
San Diego Supercomputer Center

Meshviewer Introduction

- Interactive Visualization of Large Volumes
- Multiple Volume Support
- Multiple Cameras Support
- Camera Fly Through Animation Support
- Client/Server Volume Rendering Support
- Gforce4 Texture based Volume Rendering

Required Hardware & Software

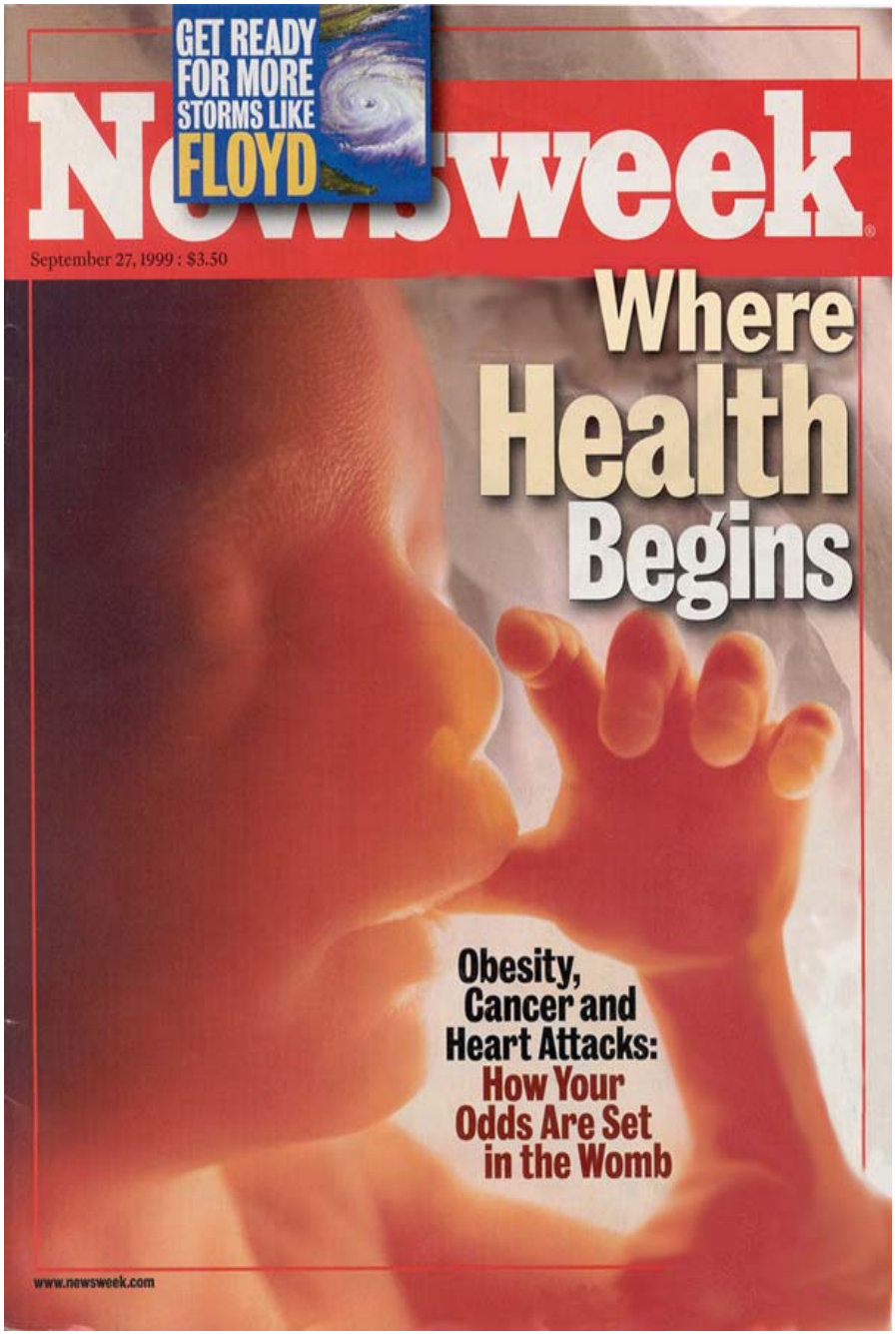
- Windows, Linux, SGI, Sun
- Java and C++
- Recommend Gforce 4 AGP card

Visible Embryo Demonstration

- Working with registered version of embryo 836
- Interactively generate a fly-through
  - Define camera positions
  - Define fly-through path
  - Render the image
  - Play the image

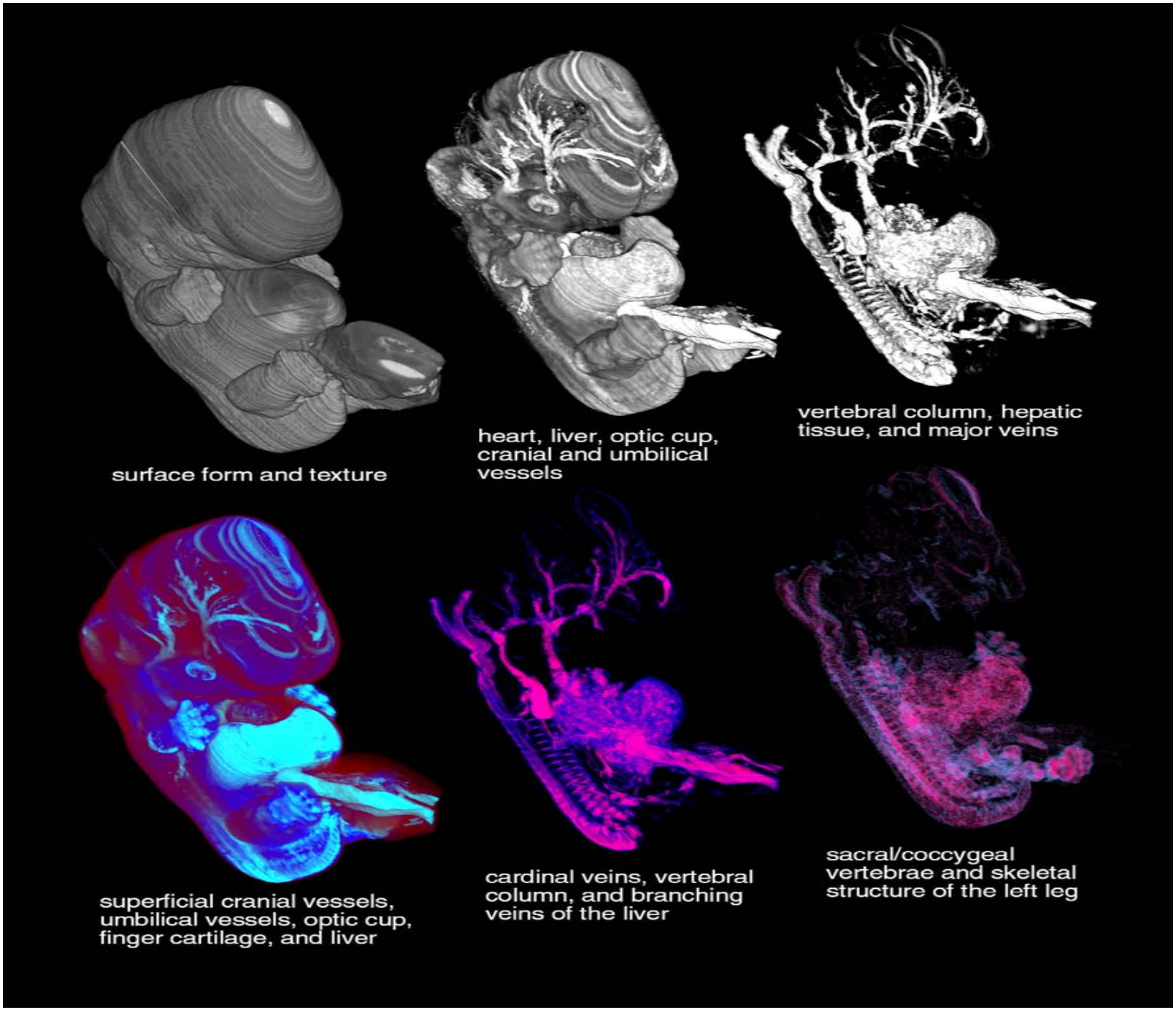
Transvaginal Ultrasonography and the Carnegie Collection: Clinical Applications of the Visible Embryo Project

Charles N. Paidas, MD
The Johns Hopkins Medical Institutions

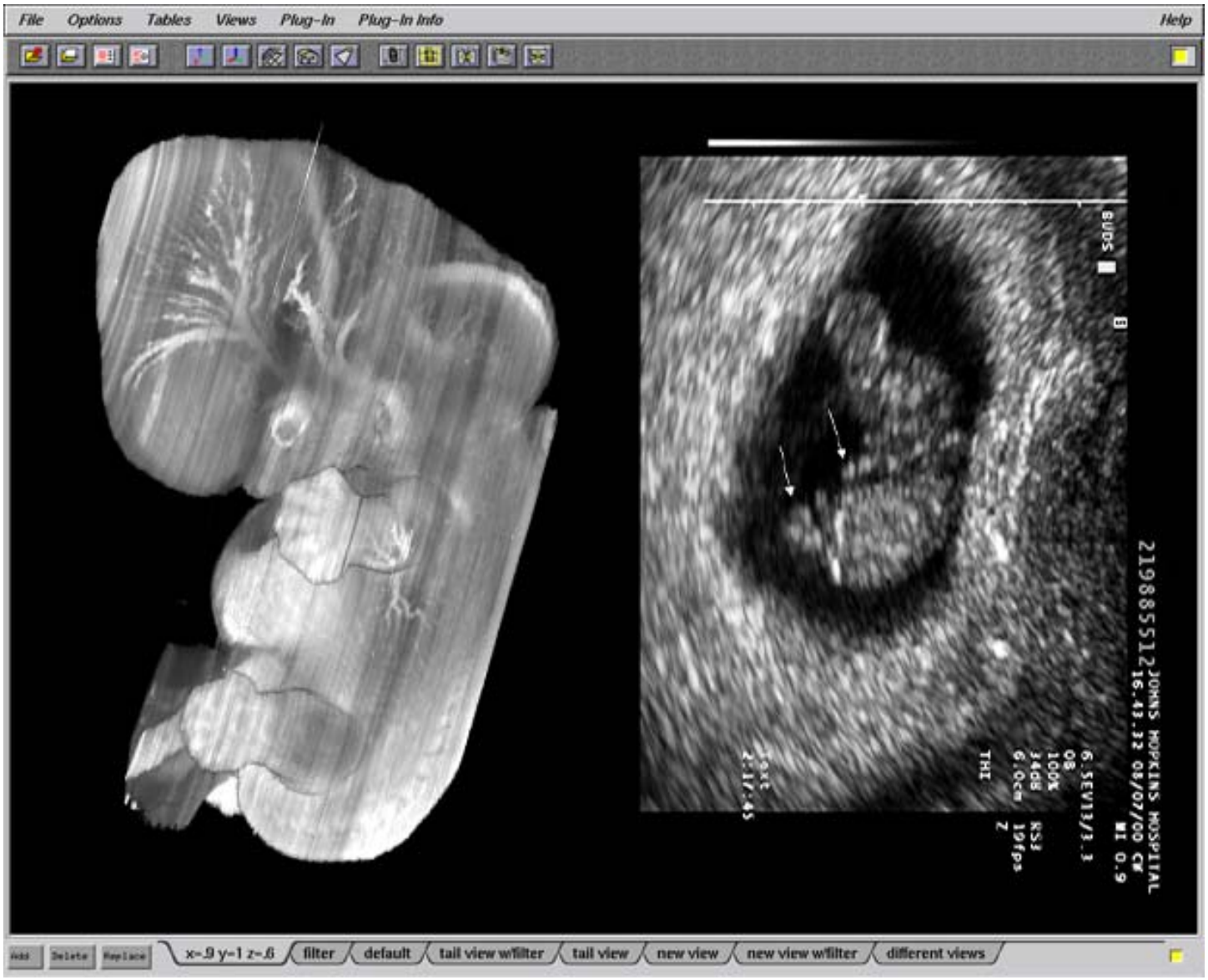


The new science of *Fetal programming* suggests that as a pregnancy progresses, each month in the womb shapes your health for life

Crown Rump Length says nothing about <u>morphology</u>


surface form and texture
heart, liver, optic cup, cranial and umbilical vessels
vertebral column, hepatic tissue, and major veins
superficial cranial vessels, umbilical vessels, optic cup, finger cartilage, and liver
cardinal veins, vertebral column, and branching veins of the liver
sacral/coccygeal vertebrae and skeletal structure of the left leg

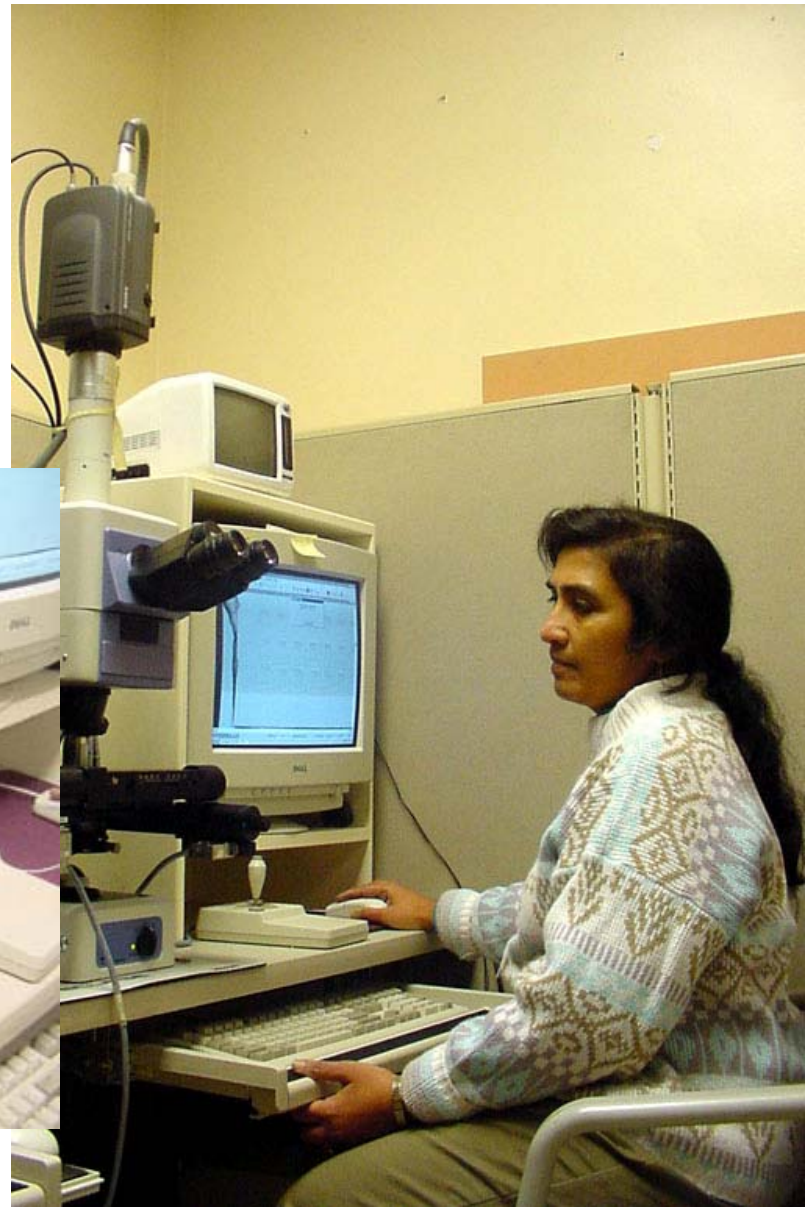
CS 18 (9 wks post LMP)



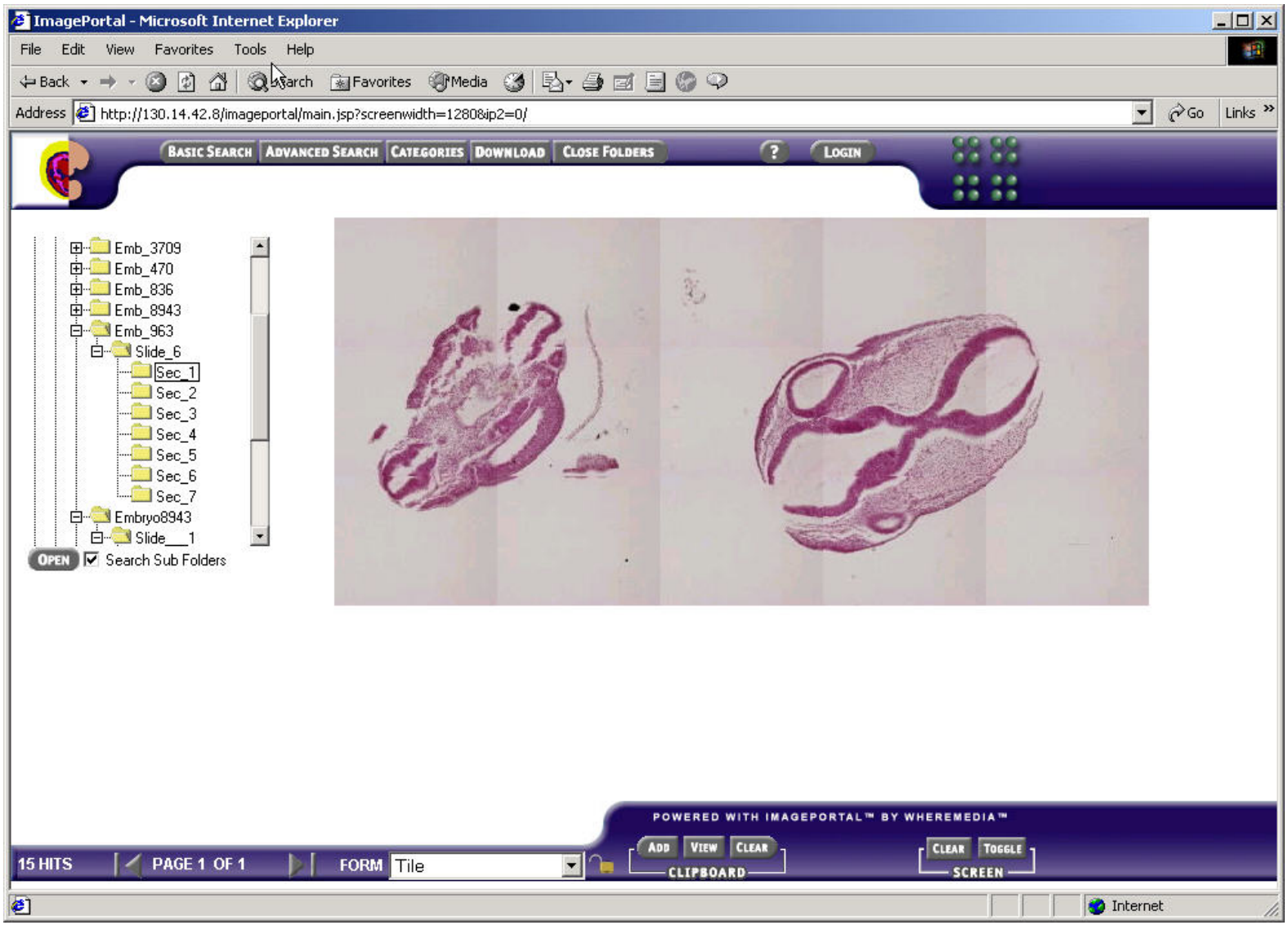
Network Accessibility for the Broader Community

Dr. Adrianne Noe
National Museum of Health and Medicine

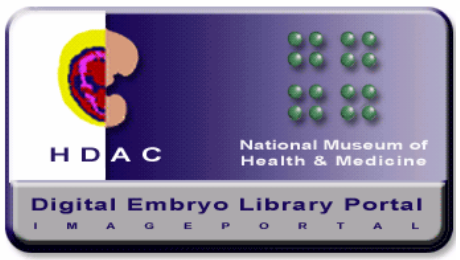
Digital Embryo Library- imaging



Imageportal to Digital Embryo Library-histology



Imageportal to Digital Embryo Library



http://130.14.42.8/imageportal